Quarterly Technical Progress Report

for the period ending June 30, 2001

METHANE de-NOX® for Utility PC Boilers

Covering Period: April 1, 2001 to June 30, 2001

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DISCLAIMER

ABSTRACT

The project seeks to develop and validate a new pulverized coal combustion system to reduce utility PC boiler NO_x emissions to 0.15 lb/million Btu or less without post-combustion flue gas cleaning. Work during the quarter included continuation of the equipment fabrication effort for pilot system components. Successful proof-of-performance testing of the IGT-designed pilot-scale natural gas-fired coal preheat combustor was completed by IGT during the quarter. The combustor was then disassembled and shipped for installation in the pilot-scale test system in BBP's Coal Burner Test Facility (CBTF) in Worcester, MA. Delivery of the balance of the pilot system components from the fabricator began near the end of the quarter, with components being installed in the pilot test facility as they were received.

EXECUTIVE SUMMARY

Project Objectives: The overall project objective is the development and validation of an innovative combustion system, based on a novel coal preheating concept prior to combustion, that can reduce NO_x emissions to 0.15 lb/million Btu or less on utility pulverized coal (PC) boilers. This NO_x reduction should be achieved without loss of boiler efficiency or operating stability, and at more than 25% lower levelized cost than state-of-the-art SCR technology. A further objective is to make this technology ready for full-scale commercial deployment by 2002-2003 in order to meet an anticipated market demand for NO_x reduction technologies resulting from the EPA's NO_x SIP call.

Background: Conventional measures for NO_x reduction in PC combustion processes primarily rely on combustion modifications and post combustion controls. In general, combustion modification technologies try to reduce the formation of NO_x precursors while destroying already-formed NO_x. A variety of NO_x reduction technologies are in use today, including Low-NO_x Burners (LNB's), flue gas recirculation (FGR), and gas or other fuel reburning. Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) are post combustion techniques. NO_x reduction efficiencies from these technologies vary from 30 to 60%, with up to 90% for SCR.

A novel pulverized coal-preheating approach for NO_x reduction has been developed by the All Russian Thermal Engineering Institute (VTI), in Russia, for use on PC utility boilers. The technology consists of a burner modification that preheats pulverized coal to elevated temperatures (up to 1500°F) prior to coal combustion. This releases coal volatiles, including fuel-bound nitrogen compounds, into a reducing environment, which converts the coal-derived nitrogen compounds to molecular N_2. The quantity of natural gas fuel required for PC preheating is in the range of 3 to 5% of the total burner heat input. Basic combustion research and development of the preheat PC burner was conducted by VTI in the early 1980's. Following these promising laboratory results, commercial-scale coal preheat burners of 30 and 60 MW_t capacity were developed and demonstrated in field tests conducted in several Russian power stations.

The advanced pulverized coal (PC) preheat combustion system being developed in this project for direct-fired PC boilers combines the modified VTI preheat burner together with elements of

IGT's successful METHANE de-NOX technology for NO_x reduction. METHANE de-NOX has been commercially demonstrated on coal, MSW and biomass-fired stoker boilers in the U.S. and Japan. Overall, the new PC preheat system combines several NO_x reduction strategies into an integrated, low-NO_x, PC combustion system, including a novel PC burner design using natural gas-fired coal preheating, and internal and external combustion staging in the primary and secondary combustion zones. This integrated system can achieve very low NO_x levels – down to 0.15 lb/million Btu – without the complications, limitations and expense of SCR or SNCR technology.

Status:

Proof-of-performance testing of the gas-fired PC Preheat (PCP) combustor was started and successfully completed by IGT during the quarter. The combustor was then shipped to BBP for installation in the pilot-scale test system. Fabrication of the pilot-scale test system components was largely completed by BBP's fabricator and delivery of the components to the test site started near the end of June. Installation of the pilot scale system in BBP's 3-million Btu/h test facility, including equipment, piping, electrical and controls is scheduled to be completed in early September.

EXPERIMENTAL

Task 1.1 *Pilot-Scale Design*

The pilot-scale system design development was completed and reported during the 4th quarter of 2000.[1]

Task 1.2 *CFD Modeling*

Development of a CFD model of the PC preheater was completed during the 4th quarter of 2000, along with the modeling study of the 3-million Btu/h pilot-scale PC Preheat combustor. Modeling of the 100-million Btu/h PC Preheat prototype system, including the PCP gas combustor, the coal burner and the BBP test furnace, will be started once pilot-scale operating data is available.

Task 1.3 *Pilot-Scale Equipment Fabrication and Installation*

PCP Combustor Pretesting

Proof-of-performance testing of the pilot-scale natural gas-fired PCP combustor in IGT's combustion laboratory was successfully completed prior to prior to installation of the combustor in BBP's research facility in Worcester, MA for integrated testing with pulverized coal.

IGT's testing was conducted to confirm combustor performance and stability while feeding #16 silica sand as a surrogate for pulverized coal. The size distribution and specific heat of the sand particle used in GTI's testing was similar to size distribution of the selected coals (see Table 1.)

[1] Quarterly Technical Progress Report for the period ending December 31, 2000
"METHANE de-NOX® for Utility PC Boilers, " DE-FC26-00NT40752

Table 1. Screen analysis for silica sand # 16 used for PCP unit testing

U.S. Sieve	120	140	170	200	230	270	325	Total
Percent retained	5.1	22.7	26.5	24.4	13.4	5.9	2.0	100

Sand was supplied into a specially designed (PC/Air) mixer by an Acrison Model BDF-1.5 volumetric feeder. In the PC/Air mixer, solids at ambient temperature were mixed with a small amount of air in controlled proportions and then introduced into the PCP combustor. The mass flow rate of solids exceeds the mass flow rates of natural gas and air. Therefore, one of the main test goals was to explore stability of natural gas combustion in the PCP combustor and find operation regimes where the flame was not extinguished by the injected cold particles. Flame stability testing was performed by varying the amount of injected solids from 20% to 160% of design solids loading. The natural gas flame remained stable through the whole load range.

The burner wall temperature was monitored by thermocouples installed on both the outer walls of the combustion chamber and the inside of the combustion chamber. The temperature of the gas/air mixture was monitored also in the gas/air plenum upstream of the nozzles. Temperature measurements showed uniform temperature distribution on the burner walls, and no hot spots were detected during the testing. The temperature of the gas/air mixture injected into the combustion chamber was about 100 °F.

The tests demonstrated stable, pulsation-free operation of the PCP combustor, uniform temperature distribution inside the burner, and combustion stability at solids loads of 20% to 160% of design load value.

Pilot Test Unit Installation at BBP

Fabrication of the pilot scale PC Preheat test unit components was completed during the quarter with the exception of the PC separator, which will be used in a later stage of pilot-scale testing. All fabricated components have been delivered to BBP's Pilot Scale Combustion Facility (PSCF) and installation on the refurbished 3-million Btu/h test furnace was started near the end of the quarter. See Figures 1 through 4. A P&ID for the pilot unit is shown in Figure 5. Installation of the pilot unit at BBP is now scheduled for completion in mid-September, with system checkout and commissioning expected by the end of September.

Task 1.4 *Pilot-Scale Testing*

Pilot operation of the PCP unit with two modes of pulverized coal delivery, a bin storage delivery system and a direct-fired delivery system will be evaluated. Key operating variables to be tested are coal type, preheat temperature and coal residence time at temperature prior to the coal combustor.

Figure 1. 3-million BTU/h PC Preheat test unit at BBP's Pilot Scale Combustion Facility (PSCF) in Worcester, MA

Figure 2. Variable length preheating chamber permits testing with various preheating residence times

Figure 3. Gas-fired PCP combustor provides rapid heating of PC in an oxygen-starved environment

Figure 4. Air-staged PC burner combusts preheated char and pyrolysis products produced in the PCP combustor

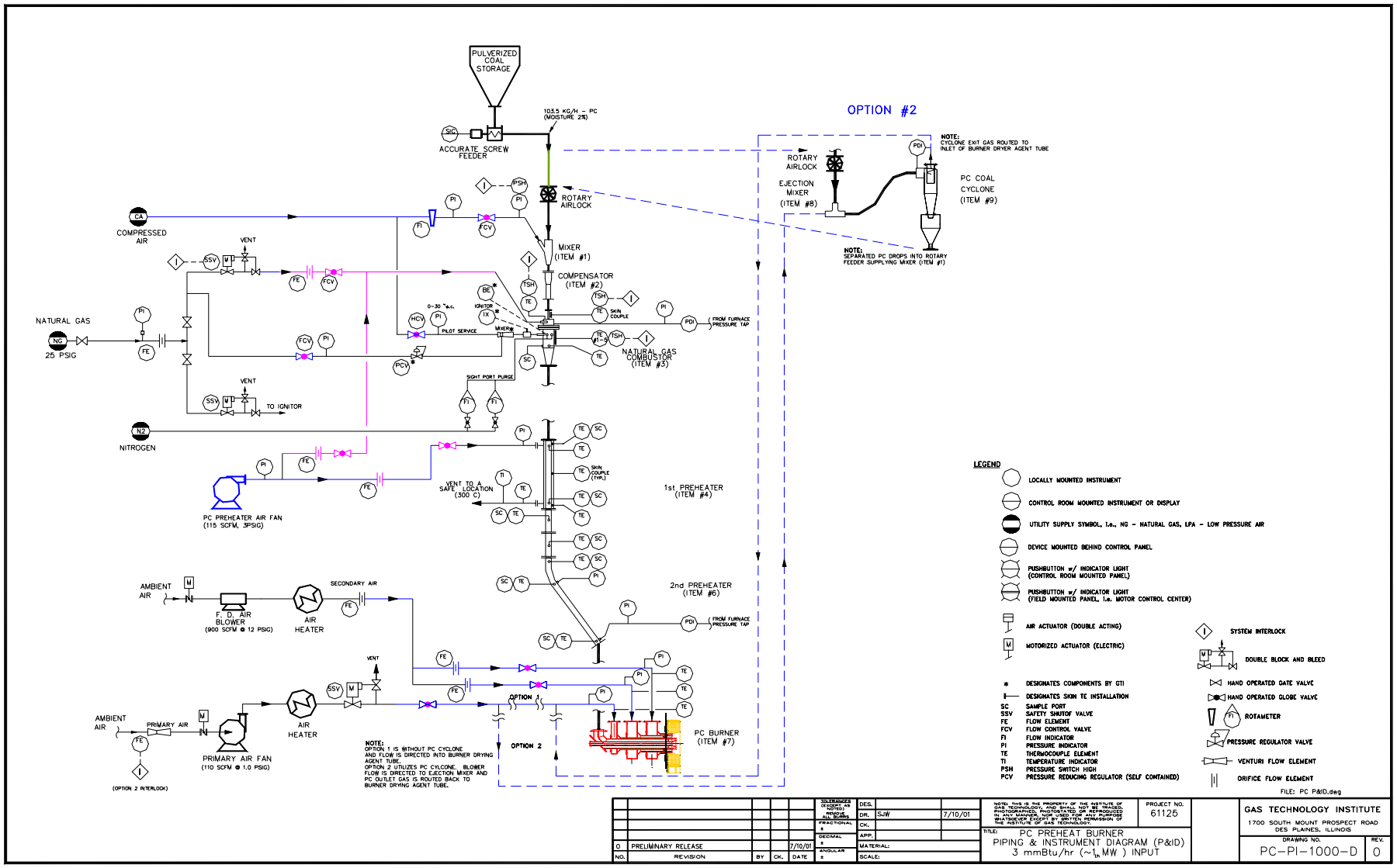

Figure 5. P&ID for the pilot-scale PC Preheat Burner Test System currently being installed at BBP's Pilot Scale Combustion Facility (PSCF) in Worcester, MA

Task 1.5 *Pilot-Scale Data Evaluation* – No Activity

Task 1.6 *Task 1 Management and Reporting*

Work during the quarter included project review and planning correspondence with VTI and BBP, follow-up with vendors for pilot-scale test system and follow-up on the contract modification with BBP for the additional design and fabrication work on the pilot system added to BBP's subcontract workscope.

Plans for Next Quarter:

- A progress review meeting will be held at BBP near the end of July to review pilot unit installation progress, define specific coals to be procured for testing, and finalize pilot unit control, data acquisition, and interlock requirements.
- Installation of the pilot unit will be completed at BBP and commissioning and startup of the unit initiated.

Milestone Status Table: The planned completion dates for all project tasks and major milestones are shown in the following table. As of this date, IGT expects the overall project to be completed on schedule in August 2002.

ID No.	Task / Milestone Description	Planned Completion	Actual Completion	Comments
♦	Kickoff Meeting	5/2/2000	5/2/2000	Complete
1.0	Technology Development			
1.1	Pilot-Scale Design	8/31/2000	12/31/2000	Complete
1.2	CFD Modeling	6/30/2001		Pilot-scale modeling complete
1.3	Pilot-Scale Equipment Fabrication and Installation	11/30/2000		Completion expected 8/2001
1.4	Pilot-Scale Testing	3/31/2001		Testing to start 9/2001
1.5	Pilot-Scale Data Evaluation	4/30/2001		Completion expected 12/2001
1.6	Task 1 Management and Reporting	4/30/2001		Completion expected 12/2001
♦	Task 1 Report	4/30/2001		Completion expected 12/2001
2.0	Technology Validation			
2.1	Commercial Prototype Engineering Design	7/31/2001		
2.2	Baseline Data Review	7/31/2001		
2.3	Commercial Prototype Construction	10/31/2001		
2.4	Commercial Prototype Testing	2/15/2002		
2.5	Data Processing and Evaluation	3/31/2002		
2.6	Commercialization Plan Development	6/15/2002		
2.7	Design and Fabrication of Commercial Burner System	7/31/2002		
2.8	Task 2 Management and Reporting	8/10/2002		
♦	Final Report	8/10/2002		